

**ECF No. 281-73, Exhibit 66 to Plaintiffs' Mot. for Class
Certification**

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Exhibit 66

**UNITED STATES DISTRICT COURT FOR THE
NORTHERN DISTRICT OF CALIFORNIA**

DZ Reserve and Cain Maxwell (d/b/a Max
Martialis) individually and on behalf of others
similarly situated,

Plaintiffs,

v.

FACEBOOK, INC.,

Defendant.

Case No. 3:18-cv-04978

**EXPERT REPORT OF ARMANDO LEVY, Ph.D.
IN SUPPORT OF PLAINTIFFS' MOTION FOR CLASS CERTIFICATION**

DECEMBER 22, 2020

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TABLE OF CONTENTS

I. INTRODUCTION.....	1
A. QUALIFICATIONS	1
B. ASSIGNMENT AND SUMMARY OF CONCLUSIONS	2
II. FACEBOOK’S SOCIAL MEDIA PLATFORMS: FACEBOOK AND INSTAGRAM.....	3
III. BACKGROUND ON THE ONLINE ADVERTISING MARKET	5
IV. THE SUPPLY OF FACEBOOK AD SLOTS	10
A. FACEBOOK ADJUSTS SUPPLY THROUGH THE TRADEOFF WITH ORGANIC CONTENT	11
V. SOCIAL AND SEARCH PLATFORMS ARE NOT SUBSTITUTABLE FOR GIVEN AD CAMPAIGN OBJECTIVE.....	13
A. ADVERTISING OPPORTUNITIES THROUGH THE CONVERSION FUNNEL	14
B. IDENTIFYING FACEBOOK’S MOST-DIRECT COMPETITORS	19
(1) Price Analysis	19
VI. PRELIMINARY DAMAGES ESTIMATE.....	23
A. ESTIMATED CHANGE IN BUDGETS FOR FACEBOOK AD CAMPAIGNS.....	23
B. THE ESTIMATED CHANGE IN ADVERTISER CPM FOR FACEBOOK AD CAMPAIGNS	24
C. ESTIMATED DAMAGES FOR THE CLASS	27
VII. CONCLUSIONS.....	30
APPENDIX A: CURRICULUM VITAE OF ARMANDO LEVY	1
APPENDIX B: DOCUMENTS RELIED UPON	1
APPENDIX C: ESTIMATING THE DAILY ADVERTISING BUDGET	1
APPENDIX D: SUMMARY TABLES USING FACEBOOK ADVERTISER DATA	1

I. INTRODUCTION

A. QUALIFICATIONS

1. My name is Armando Levy. I am an economist and Principal at The Brattle Group, Inc., a consultancy with offices in Boston, Washington D.C., Chicago, San Francisco, New York, Toronto, Madrid, Rome, London, Brussels and Sydney. I am currently the Office Director of Brattle's San Francisco office. I hold a Ph.D. in Economics, an M.A. in Statistics, and an A.B. in Applied Mathematics from the University of California at Berkeley.
2. I am an expert economist specializing in microeconomics, econometrics, and statistics. I have consulted on many litigation matters including the LCD-TFT, SRAM, DRAM, Milk and BCBS antitrust actions in the U.S. as well as antitrust proceedings in Australia. I was the testifying expert on damages in the SRAM direct-purchaser antitrust matter. I have offered testimony in federal and state courts. I have opined on the estimation of changes in equilibrium prices for automobiles given estimated changes in willingness to pay from a survey.
3. Formerly, I was an Assistant Professor of Economics at North Carolina State University and a lecturer in econometrics at the University of California at Berkeley (most recently during the Spring 2019 term). I have published numerous papers in peer-reviewed journals, including the *Journal of Labor Economics*, the *International Journal of Industrial Organization*, and *Economics Letters*.
4. A copy of my current curriculum vitae including my testimony and publications is attached as Appendix A. The Brattle Group is currently compensated at a rate of \$625 per hour for my time working in this matter and the rates for others Brattle staff working at my direction range from \$95 to \$600 per hour. Neither my compensation nor that of The Brattle Group is contingent on my findings or the outcome of this proceeding.

B. ASSIGNMENT AND SUMMARY OF CONCLUSIONS

5. Plaintiffs in this matter allege that Facebook falsely represents the “potential reach” of advertising campaigns that advertisers run on Facebook’s social media platforms.¹ Counsel for Plaintiffs in this matter have retained me to determine whether class-wide damages may be reliably estimated on a common class-wide basis, and if so to provide a calculation of those damages. In order to complete my assignment, I rely on the analyses performed by two other experts: Professor Greg Allenby of The Ohio State University, an economist who is a renowned expert on survey research using conjoint analysis, and Professor Tim Roughgarden of Columbia University, a computer scientist who is a renowned expert on computer algorithms. In performing my analysis, I pay particular attention to supply-side factors that would affect how advertising rates were determined in the market equilibrium. I do not offer any opinion on the legality of the Defendants’ actions, but assume Plaintiffs’ allegations as stated in their consolidated complaint are true.
6. Based on my review of the evidence in this matter, I conclude that damages to the class can reliably be calculated on a class-wide basis using common evidence. Specifically, I find that:
 - Facebook’s supply of ad placement opportunities is mostly fixed with respect to advertiser demand at any point in time.
 - Moreover, Facebook does not adjust the balance between organic bids and paid ads—which determine supply—according to actions by its competitors. That is, tactical decisions on how Facebook manages the balance between organic bids and paid ads do not depend on tactical decisions made by companies (such as Google and Amazon) that run platforms that also provide digital advertising. That is due, in part, to Facebook focusing on user experience when determining supply and the fact that Facebook’s platform does not have a close substitute.

¹ *Third Consolidated Class Action Complaint in DZ Reserve, et. al. v. Facebook Inc.* Case No. 3:18-cv-04978.

- Professor Roughgarden's Auction Simulation includes Facebook's supply response to a decrease in advertiser budgets because the Auction Simulation includes advertising competing with organic content. In Dr. Roughgarden's Auction Simulation, as budgets decrease, paid advertisement slots can be replaced by organic content, i.e., a decrease in supply. Thus, Professor Roughgarden has calculated a price premium that considers both supply and demand.
 - Based on the survey results provided by Professor Allenby and a simulation of auction outcomes performed by Professor Roughgarden, I calculate a preliminary estimate of class-wide damages on a common basis of \$3.8 billion dollars.
7. To prepare this report, I reviewed data provided by Facebook through discovery, academic sources, and publicly available third-party information. A list of documents that I relied upon in preparing this expert report is attached as Appendix B. I reserve the right to revise my analysis and opinions should additional relevant information be provided to me.
8. The report is organized as follows. In the next section, I describe the Facebook and Instagram social media platforms. Section III specifically describes the advertiser market side of Facebook's platform and online advertising markets generally. Section IV describes the mechanics of how auctions are managed on Facebook's ad platform and the relationship between the supply of advertising opportunities and advertiser expenditures on Facebook's platform. The penultimate section, presents a preliminary estimate of class-wide damages. A final section concludes.

II. FACEBOOK'S SOCIAL MEDIA PLATFORMS: FACEBOOK AND INSTAGRAM

9. Facebook famously began as a social networking site for students at Harvard University in 2004 and since that time, it has grown into one of the most highly valued companies in the world.² At a high level, the Facebook and Instagram (which

² See Phillips, Sara (2007) "A brief history of Facebook" The Guardian 25 July 2007 [<https://www.theguardian.com/technology/2007/jul/25/media.newmedia>] assessed 8 August 2020.

Facebook purchased in 2012) platforms provide their users a means to share personal communications (including pictures and video) on the internet with a wide network of family, friends, and acquaintances. Because content that users share on the Facebook platforms is personal, Facebook is able to amass a considerable amount of private information about its users and their personal interests.

10. Facebook became accessible to the public on September 26, 2006, when the social media platform expanded to allow anyone with a valid email address to register.³ The product further expanded on January 10th of the following year with the launch of a mobile page and support for access on cell phones.⁴
11. However, monetization efforts did not start until 2012, when Facebook began displaying advertisements on users' newsfeeds. Facebook started to monetize by allowing advertisers to place digital ads mixed in with the content provided by a users' personal network. These included proactive business page advertisements that could be displayed on feeds of users who had yet to "like" the product advertised⁵ and video advertisements on every user's newsfeed.⁶ Currently, Facebook is the dominant social media company in the United States, deriving most of its revenue from advertising on its social media platforms Facebook and Instagram.⁷
12. Advertising slots in a particular user's feed or story are sold to advertisers through a second price auction whereby advertisers bid a monetary sum for placement (or

As of November 22, 2020, Facebook had a market cap of \$768.2B. See "FB:US." Bloomberg.com. Bloomberg. Accessed November 22, 2020. <https://www.bloomberg.com/quote/FB:US>.

³ "Facebook Expansion Enables More People to Connect with Friends in a Trusted Environment." About Facebook, September 26, 2006.

⁴ Arrington, Michael. "Facebook Goes Mobile." TechCrunch. TechCrunch, January 10, 2007.

⁵ Greenfield, Rebecca. "2012: The Year Facebook Finally Tried to Make Some Money," October 30, 2013.

⁶ Rosa, Anthony De. "Facebook Brings New Ad Opportunities to Brands." Reuters. Thomson Reuters, February 29, 2012.

⁷ "We generate substantially all of our revenue from advertising." "Our financial performance has been and will continue to be significantly determined by our success in adding, retaining, and engaging active users of our products, particularly for Facebook and Instagram." Facebook Inc. 10K, 2019

“impression”).⁸ Commercial bids compete with so-called “organic” content such as a post from a friend or family member. These auctions for space in a user’s feed are numerous and occur in a small fraction of a second.

13. Plaintiffs allege that Facebook has misrepresented the amount of “potential reach” its Facebook and Instagram platforms have on audiences that advertisers specify in designing their advertising campaigns. Facebook defines “potential reach” as “an estimation of how many people are in an ad set’s target audience.”⁹ Specific examples cited in the complaint show Facebook claiming to be able to reach more people in certain groups than exist according to Census data.¹⁰ Professor Greg Allenby has estimated the effects of exaggerated reach on the choice of advertising budgets by advertisers. Furthermore, Professor Tim Roughgarden has estimated the effect of the changed budgets of advertisers on Facebook’s auction outcomes through a simulation of their auction algorithms. This report summarizes my analysis as to the effects of a supply response and my preliminary estimate of class-wide damages.

III.BACKGROUND ON THE ONLINE ADVERTISING MARKET

14. Facebook states in its most recent 10K filing that, they compete with “... companies that sell advertising, as well as with companies that provide social, media, and communication products and services that are designed to engage users on mobile devices and online.” Although, Facebook theoretically competes with traditional advertising outlets such as advertisements placed in newspapers, magazine, radio and television, no traditional outlets can provide the level of engagement and targeting that

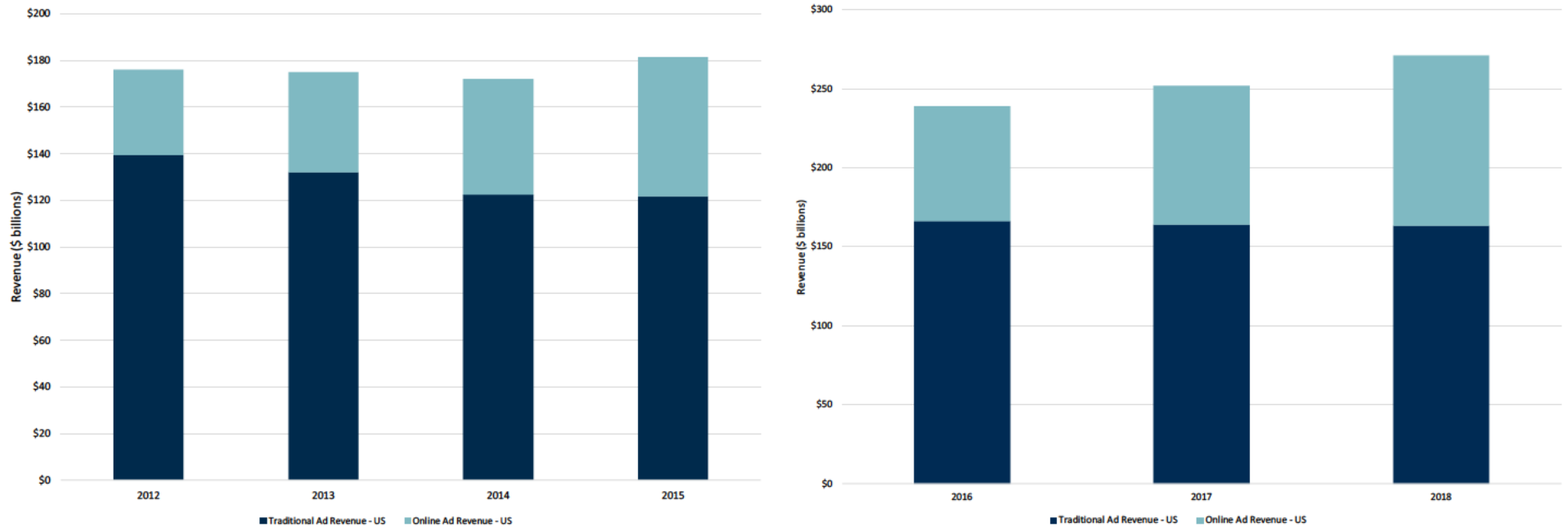
⁸ Advertisers may also pay based on clicks or other “actions” a user may take (such as installing an app). These rates are converted into an expected cost per impression, however.

⁹ Facebook Inc.’s Second Set of Interrogatories Responses, Case No. 3:18-cv-04978-JD

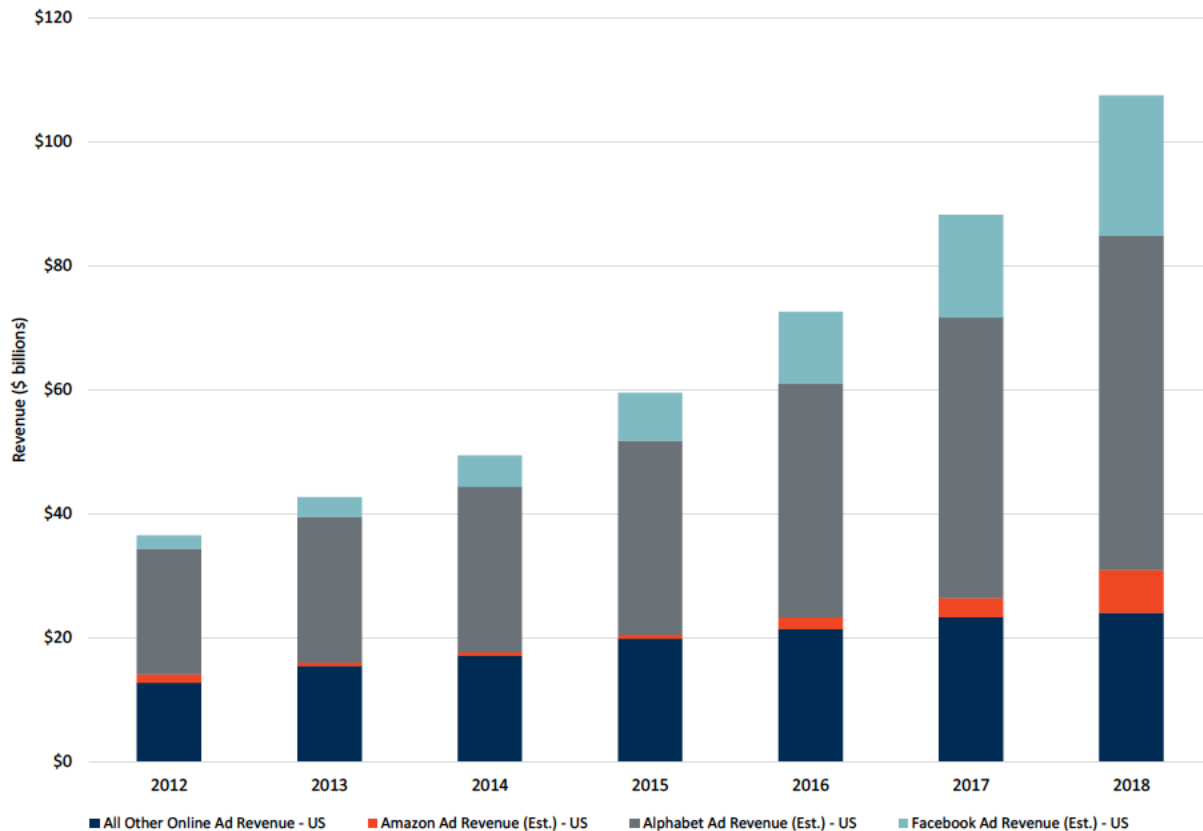
¹⁰ “For example, based on publicly available data, Facebook’s purported Potential Reach among the key 18-34 year-old demographic in every state exceeds the actual population of 18-34 year-olds... Facebook asserted its Potential Reach was approximately 4 times (400%) higher than the number of real 18-34 year-olds with Facebook accounts in Chicago... Facebook’s asserted Potential Reach in Kansas City was approximately 200% higher than the number of actual 18-54 year-olds with Facebook accounts in Kansas City. This inflation is apparent in other age categories as well.” See *Third Consolidated Class Action Complaint* in *DZ Reserve, et. al. v. Facebook Inc.* Case No. 3:18-cv-04978, pp. 1-2.

can be achieved with digital advertisements on Facebook's platforms.

15. Digital advertising allows companies to place advertisements on websites or in apps alongside the content that draws visitors to the property. Early on, advertisers simply "rented" space on the webpages for a period of time, but now advertisers may bid on space that is served to a particular user. Because digital platforms such as Google, Bing, Facebook, and Instagram are able to gather detailed information on users through cookies and keyword searches, advertisers are able to target ads to particular demographics and interests. For example, a company selling laundry detergent may target users on Google who search for "laundry" or "detergent."
16. The ability to target specific audiences that are most inclined to become customers has revolutionized the advertising industry and digital advertising has grown to be the largest channel of advertising in the U.S. Figure 1 below displays revenue from traditional and online advertising from 2012 to 2018. I split the figure into two panels: the first covering 2012-2015 and the second from 2016 to 2018. The split occurs because the scope of traditional media covered by the source data expanded in 2016. Traditional advertising in Figure 1 includes TV, magazine, newspaper, radio, out-of-home (such as billboards), video games, and cinema before 2016. From 2016 on, traditional advertising also includes business-to-business (B2B) ads. While traditional media revenue is in decline in both panels of Figure 1, digital advertising grows from less than \$40 billion in 2012 to over \$100 billion in 2018.
17. Figure 2 shows the shares of digital advertising revenues in the United States between 2012 and 2018 among Google, Facebook, Amazon, and other companies. Google has been the largest platform for advertising revenue, followed by Facebook, then Amazon.

Figure 1: US Online vs. US Traditional Ad Revenue (2012-2018, \$ billions)

Sources and Notes: IAB Internet Advertising Revenue Report Full Year Results (2012-2018), Internet Advertising Bureau (IAB)/PWC. Traditional Ad Revenue includes Broadcast and Cable TV, B2B, Magazine, Newspaper, Radio, Out of Home, Video Games, Cinema, and Music advertising. Business to Business (B2B) not reported from 2012-2015, Magazine only reported Consumer Magazine from 2012-2015.

Figure 2: US Online Ad Revenue vs. Major Advertiser Revenues (2012-2018, \$ billions)

Sources and Notes: IAB Internet Advertising Revenue Report Full Year Results (2012-2018), Facebook 10-K (2012-2018), Google 10-K (2012-2018), Amazon 10-K (2012-2018). Note that in the 2019 GOOG 10-K, the 2017 and 2018 numbers might not match with numbers from previous 10-K's: "Certain amounts in prior periods have been reclassified to conform with current period presentation" (GOOG 2019 10-K, p. 29). Amazon included non-retail activities such as AWS, advertising services, and co-branded credit card agreements under "Net Sales: Other" until 2015 where AWS was separated onto its own Revenue line. Prior to 2015, Net Sales were reported between "North America" and "International" with no breakout for United States. In 2016, AMZN notes that "Other" is primarily advertising services (p. 67).

18. People use the internet for many reasons including obtaining and sharing information, buying goods and services, communicating with other people, and to be entertained. These platforms offer the opportunity for more targeted advertisements than is possible in traditional broadcast media such as television or newspaper advertisements. The Facebook and Instagram platforms are social networks where people connect with each other to share information. Amazon is a shopping platform and Google is primarily a search engine. In addition, many people use the internet as their channel for news and entertainment. With respect to the digital advertisement

market, social networks, search engines, and news and entertainment platforms do not substitute for each other in terms of access to users because they focus on distinct, complimentary services that arise due to the nature of each platform's relationship with users. In particular, the Facebook and Instagram platforms do not substitute for search on Google or shopping on Amazon.

IV. THE SUPPLY OF FACEBOOK AD SLOTS

19. In oligopolistic markets where a few firms dominate a market, economic theory typically models competition among firms in one of two ways: Cournot or Bertrand competition. The former approach fits markets where the firms' products are interchangeable and firms primarily choose production levels (such as crude oil). The latter fits markets where the products firms sell are differentiated from each other and firms typically compete on prices.¹¹ In these models, firms set either prices (Bertrand) or output (Cournot) strategically accounting for the anticipated reaction of rivals when their products are substitutes for each other.¹² In equilibrium, marginal cost equals marginal revenue for all firms.
20. In order to estimate the price response to a change in demand for one firm's product, the analysis must first estimate the effect of the change on *demand* for the firm's product (how much buyers are willing to pay for each quantity offered). Second, the analysis must estimate how the firm reacts to the change in demand accounting for the competitive responses by its rivals. This second part of the analysis, estimates the *supply* response to a change in the firm's product. My analysis in this report focuses on this second part. Professor Allenby has estimated the effect of proper disclosure of potential reach on demand for Facebook impressions by its advertisers.
21. The typical analysis of the supply response to a change in demand would focus on the estimation of marginal costs and the anticipated reaction of rivals to actions taken by the firm facing a change in demand for its product. As I discuss below, there are features of Facebook's advertising business that make the analysis straightforward. For example, marginal costs of serving an ad on its platform is close to zero. Facebook itself does not track those costs.¹³ Second, none of Facebook's closest rivals controls

¹¹ A recent study of broadcast television advertising found the Cournot Model a better fit to the industry. *See*, Ivaldi, M. and Zhang, J. (2018) "Advertising Competition in the Free-to-Air TV Broadcast Industry" *Working Paper No. 15-578* Toulouse School of Economics

¹² *See for example*, Berry, S., Levinsohn, J. and Pakes, A. (1995) "Automobile Prices in Market Equilibrium" *Econometrica*, Vol. 63(4): 841-890.

¹³ See response to Interrogatory #7 of Facebook Inc.'s Third Set of Interrogatories, Case No. 3:18-cv-04978-JD.

a platform that provides a close substitute for the Facebook platform. On the other hand, one element of Facebook's business does add complexity compared to a more typical analysis. Unlike other industries where firms set prices, billions of auctions determine prices for advertisements on Facebook's platform, so that Facebook does not set prices. In order to measure the effects of changes in advertiser budgets on ad prices, Professor Roughgarden has performed an analysis of Facebook's auction outcomes.

A. FACEBOOK ADJUSTS SUPPLY THROUGH THE TRADEOFF WITH ORGANIC CONTENT

22. Although Facebook does not set prices, Facebook has an upward sloping supply schedule by virtue of the tradeoff between internal competition among "organic" content and paid advertisement on its platforms. However, there are three features that separate it from the standard case. First, the company does not explicitly set prices, but auctions advertising opportunities on its platforms on Facebook and Instagram. Second, marginal costs for serving an advertisement on through Facebook are very low.¹⁴ Hence, Facebook is effectively maximizing revenue while not setting prices. Finally, there is no rival platform that substitutes for Facebook's combination of ubiquity and ability to target advertisements. As I describe in more detail below, ad prices on Facebook's platform fall automatically in the face of lower demand through its auction mechanism.
23. As I discussed briefly above, advertising impressions on the Facebook and Instagram platforms are allocated in a [REDACTED]
[REDACTED]
24. These auctions are executed in milliseconds as millions of users of Facebook and Instagram load their feeds on a web browser or mobile device application at any

¹⁴ Fixed costs of maintaining the platform to attract and retain users, however, are significant.

¹⁵ [REDACTED] See, FB-SINGER-00187566-73. See, FB-SINGER-00186952.

moment in time. Advertisers are charged on the basis of the auctions they win (pay “per impression”), on the basis of the users who click on their advertisement (pay “per click”), or on the basis of a user performing an action such as installation of an advertiser’s application (pay “per action”).¹⁶ [REDACTED]

[REDACTED]
[REDACTED]⁷

25. The tradeoff between organic content and paid advertising is closely related to “ad load,” which is the density of advertising that is seen on the platform from a user’s perspective. [REDACTED]

[REDACTED] David Wehner, Facebook’s CFO, has explained publicly that to determine the optimal ad load, Facebook carefully tracks the impact of ads on the user experience.¹⁹ Mark Zuckerberg echoed these sentiments in the Q2 2017 earnings call, saying: “One of the factors that contributed to ad load over time is the quality of the ads. If ad quality was low, we wouldn’t be able to put as many ads in because people wouldn’t want that.”²⁰ In their own internal documentation, Facebook also acknowledges “[a]d load is a tradeoff with user value.”²¹

26. As documented above, [REDACTED]
[REDACTED]
[REDACTED]

27. The primary form of competition influencing the number of slots available for ads (i.e., advertising supply) at a particular instant is between ads and organic content. As advertisers lower demand, the number of ad impressions will decline as organic

¹⁶ See, <https://www.facebook.com/business/help/237396169733125>

¹⁷ [REDACTED]
[REDACTED] See, FB-SINGER-00186953-54.

¹⁸ Deposition of Chinmay Karande, at 92:25 – 93:8.

¹⁹ Plaintiffs’ Deposition Exhibit 130, Deposition of Chinmay Karande

²⁰ Facebook, Inc., “Second Quarter 2017 Results Conference Call,” News release, (July 26, 2017).

²¹ FB-SINGER-00003752

²² Deposition of Chinmay Karande, at 93:9-24.

content will win more placements. Dr. Roughgarden's Auction Simulation includes Facebook's supply response to a decrease in advertiser budgets because the Auction Simulation includes organic content. In Dr. Roughgarden's Auction Simulation, as budgets decrease, paid advertisement slots can be replaced by organic content. Thus, Dr. Roughgarden has calculated a price premium that considers both supply and demand.

28. Facebook monitors other companies offering digital advertising to gain insights, such as how to develop an easy-to-use interface for advertisers to place ads.²³ However, Facebook does not appear to monitor rivals when it adjusts the tradeoff between organic content and paid ads.
29. In the next section, I examine one of the reasons why Facebook does not monitor or react to rivals in adjusting its tradeoff between organic content and paid ads (i.e., changing supply): Facebook has no close substitutes for its digital advertising platform.

V. SOCIAL AND SEARCH PLATFORMS ARE NOT SUBSTITUTABLE FOR GIVEN AD CAMPAIGN OBJECTIVE

30. In rendering my opinion that Facebook lacks close substitutes, I begin with the data from Dr. Allenby's survey. Dr. Allenby finds that his conjoint survey result "indicates that Facebook and Google are not close substitutes and their demand is relatively independent of each other."²⁴ In the remainder of this section, I illustrate that search and social media advertising each offer different advertising opportunities to companies, making one medium or the other more appropriate for a given objective. To do so, I begin by discussing what in marketing is called the "conversion funnel," a metaphor for the journey a consumer takes to make a purchasing decision, and the advertising strategies used at each step.

²³ Facebook appears to regularly benchmarks their ad interface against other digital ad platforms. *See*, FB-SINGER-00103337-61, FB-SINGER-00228373.

²⁴ Expert Report of Dr. Greg Allenby, at 21.

A. ADVERTISING OPPORTUNITIES THROUGH THE CONVERSION FUNNEL

31. Ad campaigns can have a variety of goals or objectives. Facebook’s Business Help Center lists three broad categories of objectives:

- Awareness campaigns “generate interest in [a] product or service”;
- Consideration campaigns “get people to think about [a] business and seek more information”; and
- Conversion campaigns “encourage people interested in [a] business to buy or use [its] product or service.”²⁵

These three broad objectives align with the stages of what marketers call the “conversion funnel.” The widest part of the funnel introduces consumers to a particular good or service that they may have been unaware of or disinterested in. Among those who become interested in the product, a company hopes to encourage consumers to consider its particular product and become more informed. Finally, consumers are asked to act on their interest and make a purchase.²⁶

32. Marketers work with clients to target consumers in each stage of the funnel with different messages, potentially using different media. As an example, consider a company selling running shoes. It might target a wide audience through a Super Bowl commercial with a celebrity. Little specific information would be provided about their shoes and instead the focus would be on motivating people to bond with the endorsing celebrity. This “upper funnel” strategy stands in contrast to a “mid funnel” strategy that would place ads in a running magazine. Its viewers are already convinced of the benefits of running, so this ad would cite specific advantages of the company’s products. Lastly, a “bottom-of-the-funnel” strategy might involve window displays and discounts in a brick-and-mortar storefront. Each of these campaigns targets a different audience with tailored messaging through an effective medium.

²⁵ <https://www.facebook.com/business/help/1438417719786914>

²⁶ Tuten, Tracy L, and Michael R. Solomon. “Social Media Metrics.” In *Social Media Marketing*, 3rd ed., 346. Los Angeles, California: Sage, 2018.

33. The same incentives hold for online sales—an advertiser uses a particular message and medium to reach a particular audience. Given the tremendous amounts of data available on ad viewers online, these messages can be tailored to individuals to greater extent than is possible using traditional media. These data do not need to be detailed browsing histories to be useful, however; the decision of a viewer to visit a particular site is information itself. Someone searching for “running shoe reviews” is likely to make a purchase soon. A visitor to a running website is likely interested in running, though may not be looking to purchase a new pair of shoes at that time. As a final example, someone who follows health and wellness brands on Instagram may be interested in becoming a runner. For these reasons, it is not surprising that different digital properties cater to different advertising objectives.
34. Search engines like Google (aside from online retailers own sites) are often the best way for an advertiser to target those in the bottom of the funnel.²⁷ Searchers make their desires explicit in their choice of keywords and links to follow. Google lists direct sales, leads, and website traffic as the primary objectives for search campaigns, which are specific goals within the consideration and conversion levels of the funnel—and does not list a goal that would qualify as an awareness building opportunity.²⁸ Ads on these properties can be especially lucrative as they are the closest point an advertiser can get to a customer before they make a purchase.
35. Social media advertising on properties such as Facebook News Feed and Instagram are much further from a consumer with a purchase decision in mind. Facebook’s most common use for conversion advertising is mobile app downloads (notably gaming apps). This is because developers can tie specific downloads of their apps to specific views of their ads on Facebook via unique device identifiers historically made available on Apple’s iOS and (Google’s) Android mobile operating systems. Because of this direct linkage, Facebook was able to offer developers advertising pricing on a

²⁷ Google also provides ads on third-party websites via its display network and embedded in YouTube videos and alongside Gmail messages, among other locations. These are top-of-funnel locations. In discussing Google in this section, however, I focus on its search advertising business.

²⁸ <https://support.google.com/google-ads/answer/7450050?hl=en>

per install basis. Landing as far down the funnel as possible, these ads typically commanded relatively high prices.²⁹

36. The differences between search and social media advertising become apparent in comparing ad messages between Google at the bottom of the funnel and Facebook properties at the top.³⁰ The example below in Figure 3 from a Google search for “flight to Hawaii.” The Google ad directs the viewer to Hawaiian Airlines’ website and provides a list of specific destinations. In contrast to the basic text-based search ad, the airline’s Facebook ads are videos that encourage people to consider a trip to the archipelago.
37. This example demonstrates that advertisers use different strategies, in terms of overall message and visual presentation, in bottom-of-the-funnel search advertising and top-of-the-funnel social media advertising. Differences in the media lead companies to target different consumer groups with different messages. Conversely, for a given target audience and objective, advertisers will choose a different medium. For this reason, search advertising and social media advertising are not substitutable for a particular campaign and may be considered to be complimentary.

²⁹ Apple recently changed the default settings in iOS to hide the unique device identifier from apps such as Facebook by default. This is expected to have important consequences for its app advertising business. See <https://stratechery.com/2020/facebooks-ios-14-announcement-understanding-the-idfa-the-real-showdown/>


³⁰ Professor Allenby also notes the two platforms targeting different parts of the conversion funnel. See, Expert Report of Greg Allenby, p12.

Figure 3: Google Ad for Travel to Hawaii

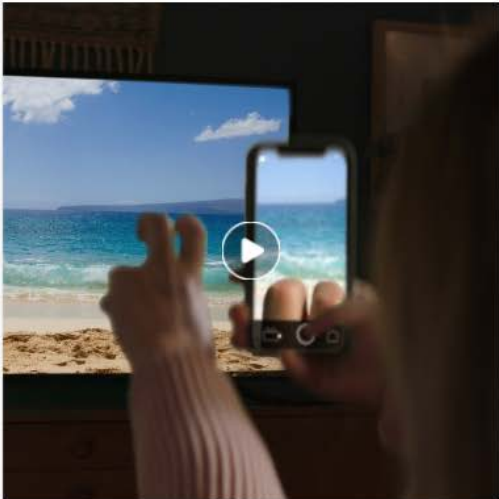
The image is a screenshot of a Google search results page. At the top left is the Google logo. To its right is a search bar containing the text "flight to hawaii". To the right of the search bar are icons for "X" and "Search". Below the search bar is a horizontal menu with links: "All", "Flights", "Images", "News", "Maps", "More", "Settings", and "Tools". Below this menu, it says "About 182,000,000 results (0.64 seconds)". The main content is an advertisement for Hawaiian Airlines. It starts with "Ad · www.hawaiianairlines.com/". The headline is "Hawaiian Airlines® - Fly To Hawaii With Us". The body text reads: "We're Looking Forward To Welcoming You Aboard. We Are Committed To The Safety Of Our Guests and Community. Award Winning Service. #1 On Time Performance. Convenient **Flight** Times. In-**Flight** Entertainment. Destinations: Honolulu, Kona, Kahului, Lihue, Hilo." Below this, there are four columns of text, each with a heading and a description:

Get Tested Before You Fly Avoid The 14-Day Self-Quarantine With a Negative COVID-19 Test.	Hawaiian Miles Join Our Frequent Flyer And Earn Miles On Your Next Flight!
Sharing Aloha Bringing You Videos Featuring Life and Culture Here in the Islands.	Keeping You Safe How We're Keeping You Safe. Our Cleaning and Safety Procedures.

Figure 4: Facebook Ad on Travel to Hawaii


**Hawaiian Airlines**
Sponsored


Beach pics are better on the beach




WWW.HAWAIIANAIRLINES.COM
It's Time To Go To Hawai'i For Real
Fly On The Airline That Knows It Best

[Book Now](#)

 **80 ads** use this creative and text


**Hawaiian Airlines**
Sponsored

Create your own memories of Hawai'i




WWW.HAWAIIANAIRLINES.COM
It's Time To Go To Hawai'i For Real
Fly On The Airline That Knows It Best


[Book Now](#)

 **80 ads** use this creative and text

[See Ad Details](#)


**Hawaiian Airlines**
Sponsored

Watch the sunset IRL



WWW.HAWAIIANAIRLINES.COM
It's Time To Go To Hawai'i For Real
Fly On The Airline That Knows It Best

[Book Now](#)

 **80 ads** use this creative and text

[See Ad Details](#)

B. IDENTIFYING FACEBOOK'S MOST-DIRECT COMPETITORS

38. When considering Facebook's primary competitors for online advertising budgets, it is necessary to look at platforms that provide high-to-mid funnel opportunities and possess detailed information on a user's general interests. Other social media platforms, like Snapchat and TikTok, do not have the depth of information on user's interests that Facebook does, nor have they monetized as extensively. Pinterest, a social media service that allows users to collect visual elements from around the web, has begun to monetize more successfully based on its users' interests and may be a prime challenger to Facebook at some point in the future. However, to this point, no other platform offers the same opportunities with as expansive a reach as Facebook and its affiliated digital properties.
39. In the remainder of this section, I consider additional, market-based evidence of which companies may compete with Facebook for advertising budgets. I first compare advertising rates on Facebook to other platforms. In the second, I consider a boycott of Facebook during the summer of 2020 due to the platform's position on restricting inflammatory posts. Neither case points to a clear, strong competitor for Facebook.

(1) Price Analysis

40. In order to ascertain the degree of potential price competition between various digital ad platforms, I collected quarterly CPM figures for Facebook's News Feed ads, Facebook's Audience Network,³¹ Facebook Messenger, Google Ads Search, Google Display Network, YouTube, Bing, LinkedIn, and Twitter from Q1 2017 to Q4 2019. The data were collected from AdStage's Paid Media Benchmark Reports. Google Ad Search and Facebook's News Feed are by far the two largest channels for digital advertising in the United States.
41. If different digital platforms were close substitutes for each other, I would expect the

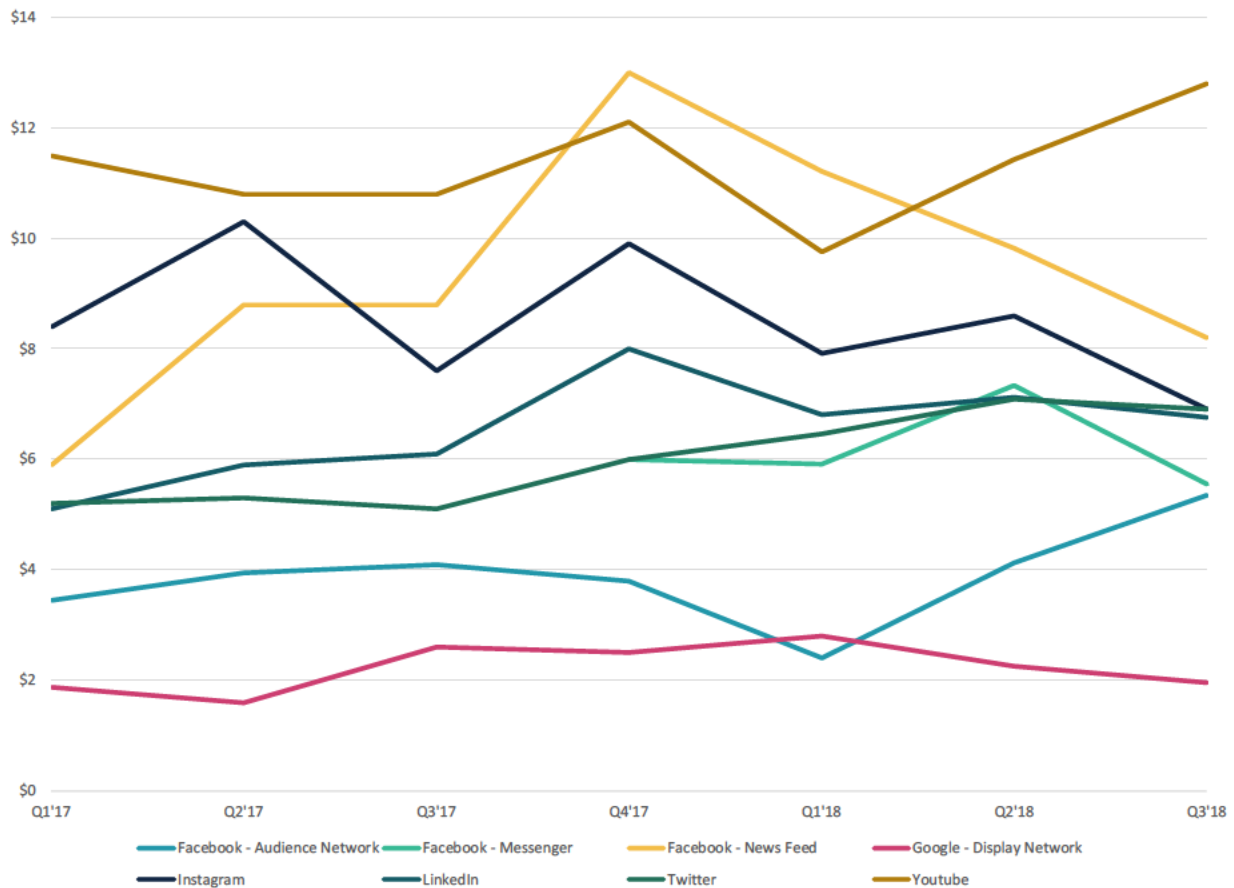
³¹ Facebook's Audience Network places ads on third party mobile apps.

CPM figures to move together because if the price differential between two substitutable platforms increased, the platform that was relatively less expensive would take business away from the more expensive platform, all else equal. Figure 5 below displays CPMs for the first 7 quarters of the time period.³² Google Ad Search and Bing are not displayed because their CPM rates are almost an order of magnitude higher (\$80 to \$120) during this period of time.³³ The two ad networks (Facebook's Audience Network and Google's Display Network) are uniformly below the CPMs of the other platforms. These services place ads on third party applications and websites, so are historically less attractive to advertisers.

³² Data after Q3 2018, splits Instagram into Feed and Stories.

³³ As I discuss elsewhere in this report, this outcome is consistent with search ads being an effective "bottom of the conversion funnel" tool versus the other platforms.

Figure 5: Median CPM for Facebook, Instagram and Other Platforms



Sources and Notes: AdStage Paid Media Q1 2018, Q3 2018, and Q4 2019 Benchmark reports.

42. I calculated the correlation between quarterly CPMs for those platforms between Q1 2017 and Q4 2019. The full set of correlations are displayed in Table 1 below. Correlation coefficients vary between -1 and 1, with a value of 1 indicating perfect co-movement of CPMs and -1 indicating perfect movement in opposite directions of CPMs. A value of zero is consistent with statistical independence. The correlation between quarterly Facebook's median CPM for News Feed and Google's quarterly median CPM for Ads Search was only 0.09 between 2017 and 2019, although those channels are the clear majority of digital ad revenue in the United States (see Figure 2).

Table 1: Correlation Among Quarterly CPM 2017-2019

	Facebook - News Feed	Facebook - Audience Network	Google - Ads Search	Google - Display Network	Youtube	Linkedin	Twitter
Facebook - News Feed	1.00	-0.33	0.09	0.40	0.07	0.33	0.11
Facebook - Audience Network		1.00	-0.82	0.16	-0.57	0.61	0.10
Google - Ads Search			1.00	-0.39	0.57	-0.81	-0.07
Google - Display Network				1.00	-0.30	0.61	0.31
Youtube					1.00	-0.51	0.34
Linkedin						1.00	0.29
Twitter							1.00

43. These results are consistent with a view that Facebook’s News Feed and Instagram News Feed and Stories are not direct substitutes for digital ads on other platforms, but more complimentary. This reflects the fact that consumers use many of these platforms, each for different reasons, a behavior called multi-homing that has been studied in the economics literature.^{34,35} I understand that Professor Allenby also found limited substitution between Facebook and other digital advertising platforms in his analysis.³⁶
44. I conclude Facebook has no close substitute in the market for digital advertising. Facebook manages the supply of advertising opportunities using the tradeoff between organic content and sponsored ads, while prices are determined by auction.

³⁴ See Athey, et. al. (2018) and D’Annzio and Russo (2020).

³⁵ A Wall Street Journal article examined how advertisers boycotting Facebook in July of this year indicated they were going to spend the digital advertising budgets they had earmarked for Facebook. There was no clear alternative to Facebook, advertisers spent their budgets on a wide variety of channel including “influencer campaigns” and outside of digital advertising altogether. See, Ives, Nat (2020) “Where Advertisers Boycotting Facebook Are Spending Their Money Instead” *Wall Street Journal*, June 29, 2020 [<https://www.wsj.com/articles/where-advertisers-boycotting-facebook-are-spending-their-money-instead-11593467895>]

³⁶ See, Expert Report of Greg Allenby, Ph.D., p 11.

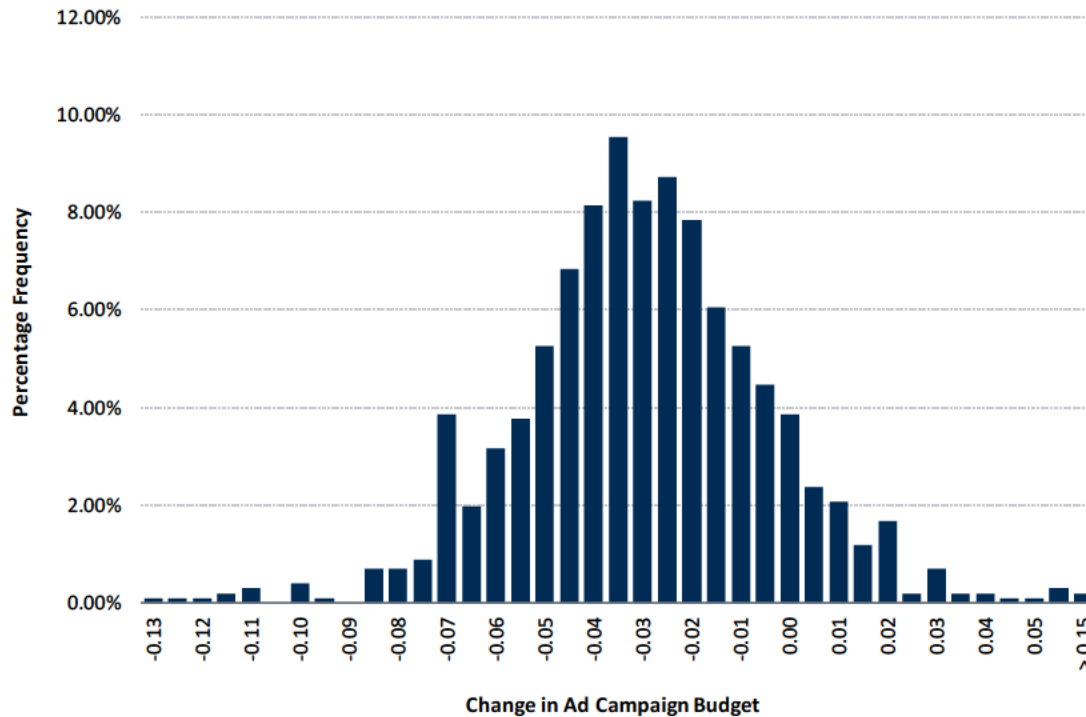
VI. PRELIMINARY DAMAGES ESTIMATE

45. In order to estimate damages to members of the class, I must estimate the effect that Facebook's misrepresentations had on the budgets the advertisers devoted to Facebook's platform. The second step is then to simulate how the changed budgets in a counterfactual with proper disclosure would have propagated through Facebook's auction algorithm and affected the CPMs paid per class member.

A. ESTIMATED CHANGE IN BUDGETS FOR FACEBOOK AD CAMPAIGNS

46. Professor Allenby's regression results provide an estimate of the distribution of changes in budgets for ad sets given (1) a change from United States Audience Size from 240,000,000 to 180,000,00 and (2) a 10 percent reduction in the audience size after targeting. Using the survey data from his conjoint choice experiment, Professor Allenby estimated the change in Facebook's share of an advertiser's digital advertising budget that would result from changes in two measurements of potential reach.³⁷ Because Professor Allenby performs his regression analysis as a Hierarchical Bayes procedure, he is able to produce a distribution of changes in Facebook budgets across advertisers. The estimated distribution of the change in budgets is given in Figure 6 below.

³⁷ Professor Allenby performed a regression of Facebook's share of an advertiser's digital ad budget on characteristics of the Facebook campaign, including the potential reach of the campaign. The average part worth for the change from U.S audience size from 240 million to 180 million is -0.75 percentage points. The change in the budget following a 10 percent reduction in targeted audience from the benchmark is 0.75 percentage points. *See*, Allenby Report, Table 3. The change in ad budget is given by $(\beta_{1i} + \beta_{2i}) / (\text{actual FB budget share}_i)$ where β_{1i} is the effect of the initial reach metric for individual i and β_{2i} is the effect of the final reach metric for individual i .

Figure 6: Histogram of the Change in Facebook Ad Campaign Budgets

47. The average change in budget for a Facebook campaign was 3.2 percent and the median was 3.3 percent. As is apparent from Figure 6, there is also meaningful variation around the mean, with some 9.3 percent of the sample actually increasing their budgets when potential reach is truthfully revealed. However, because the CPMs realized by advertisers are largely a function of the bids of *other* advertisers, I need to know the outcome of Facebook's auction algorithms given this distribution of budget changes in order to estimate damages.

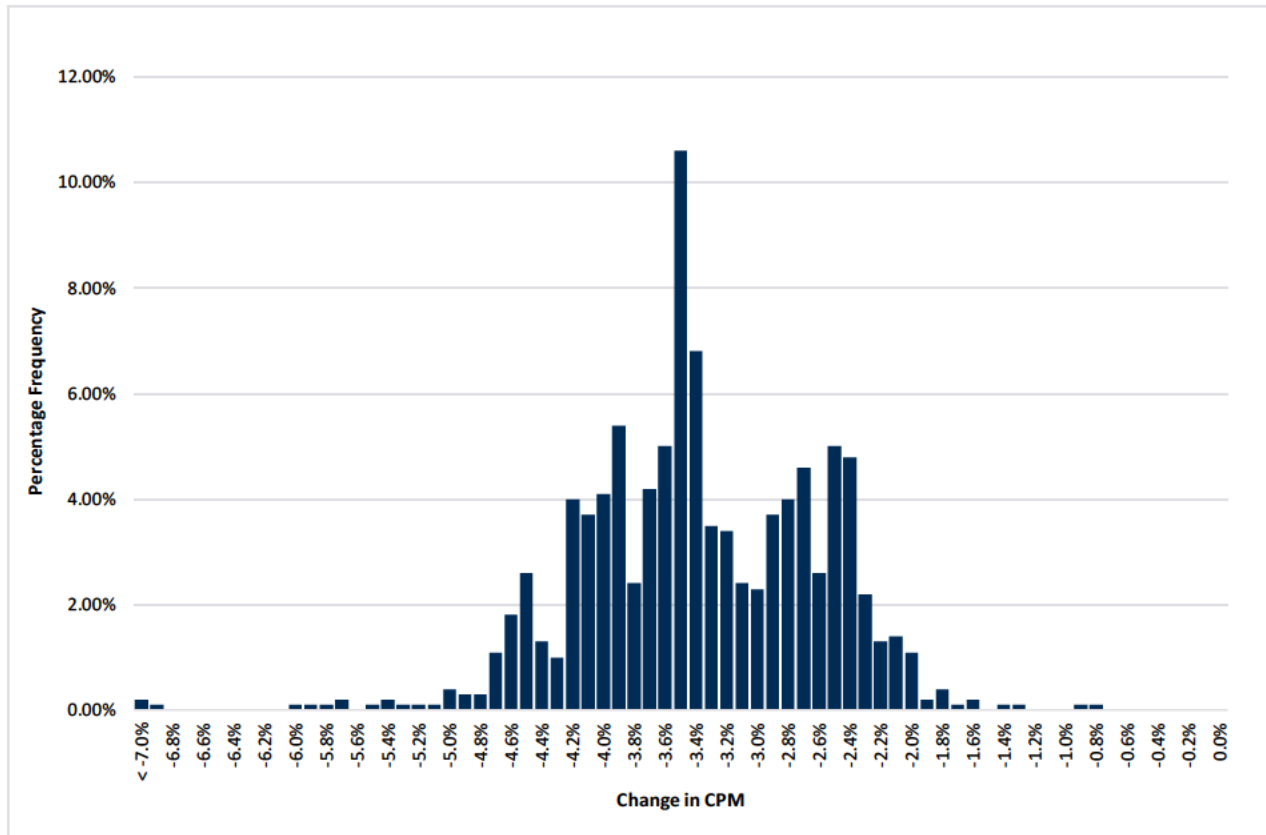
B. THE ESTIMATED CHANGE IN ADVERTISER CPM FOR FACEBOOK AD CAMPAIGNS

48. I shared the distribution of the change in budgets for advertising campaigns on Facebook shown above with Professor Roughgarden. In addition to the distribution of the change in budgets, I also shared the estimated distribution of daily ad budgets for ad campaigns on Facebook. This distribution was produced from campaign information Facebook produced in discovery and includes an almost complete

accounting for all ad campaigns running on Facebook during the first two weeks of May 2019.³⁸

49. Professor Roughgarden used the two inputs I provided him: (1) Professor Allenby's distribution of the change in Facebook ad campaign budgets, and (2) the distribution of daily budgets for Facebook ad campaigns. He then simulated the Facebook auction algorithm to estimate the change in the average CPM for each advertiser that would occur if advertisers adjusted their budgets as estimated by Professor Allenby. The distribution of the change in CPM is given in Figure 7 below. The average change in CPM is 3.4 percent.
50. Professor Roughgarden's simulation also predicts how the number of impressions served will change given the changes in budgets predicted by Professor Allenby's analysis. His results show that ad impressions drop by 0.03 percent when budgets adjust to the changes in the report potential reach as organic ads win more placements in the counterfactual equilibrium.

³⁸ Details of the analysis of Facebook's data are given in Appendix C.

Figure 7: Estimated Change in Advertiser CPM

51. As can be seen from Figure 7, although 9.3 percent of the sample in Professor Allenby's analysis *increase* their budgets with truthful revelation of potential reach, none of the advertisers in Professor Roughgarden's simulations face an increased CPM following more proper disclosure of potential reach. The reason for this is that advertisers mix together on the auction platform when they compete for ad placements and the amount that a bidder pays is dependent on the bids of other advertisers. As a result, Professor Roughgarden finds that *all* advertisers in the simulation were impacted by Facebook's misrepresentation in equilibrium.³⁹ This result is robust to changes in Professor Roughgarden's input parameters.⁴⁰

52. I note that Facebook itself estimated the revenue impact from more accurately reporting the potential reach to advertisers. Facebook had worked to address two

³⁹ Expert Report of Dr. Timothy Roughgarden, ¶62

⁴⁰ *Ibid.*, ¶¶68-72.

sources of the exaggeration of potential reach. The first process estimated the number of single users with multiple accounts (SUMA). The second process estimated users' true age rather than relying on self-reported age for targeting. Incorporating SUMA modeling into reach was thought to correct about 50 percent of the exaggeration and lower revenue between [REDACTED] percent.⁴¹ This would serve as a lower bound to the estimated 3.4 percent revenue impact I report because the SUMA correction removes only a part of the exaggeration and Facebook's analysis assumed only a reaction from brand and "reach and frequency" campaigns.⁴² At the other end of the spectrum, Facebook also estimated that removing the potential reach reporting altogether would lower revenue by 8 to 9 percent.⁴³

C. ESTIMATED DAMAGES FOR THE CLASS

53. Given the results of Professor Roughgarden's analysis, I can apply the price premium of 3.4 percent to the money paid by any advertiser or to the class as whole. For example, based on Facebook's all_ads_details data, United States advertisers spent [REDACTED] [REDACTED] between August 15, 2014 and May 15, 2019.⁴⁴ Thus, the amount of class-wide damages from August 15, 2014 to May 16, 2019 is in excess of [REDACTED] dollars. I show the results in Table 1 below where I extend the period of time to the present filling in the latest revenue figures from Facebook's 10K and 10Q reports.
54. Although Facebook has not produced its revenue for United States from May 16, 2019 to December 22, 2020, public data indicates that it is \$125.5 billion. Thus, the amount of class-wide damages from August 15, 2014 to December 22, 2020 is \$3.8 billion dollars
55. As I stated earlier, the impact reflects changes in two measures of potential reach: the potential reach for the entire United States and the potential reach after targeting.

⁴¹ FB-SINGER-00092773-4.

⁴² Professor Allenby's results show more broad based effects. See, Figure 6.

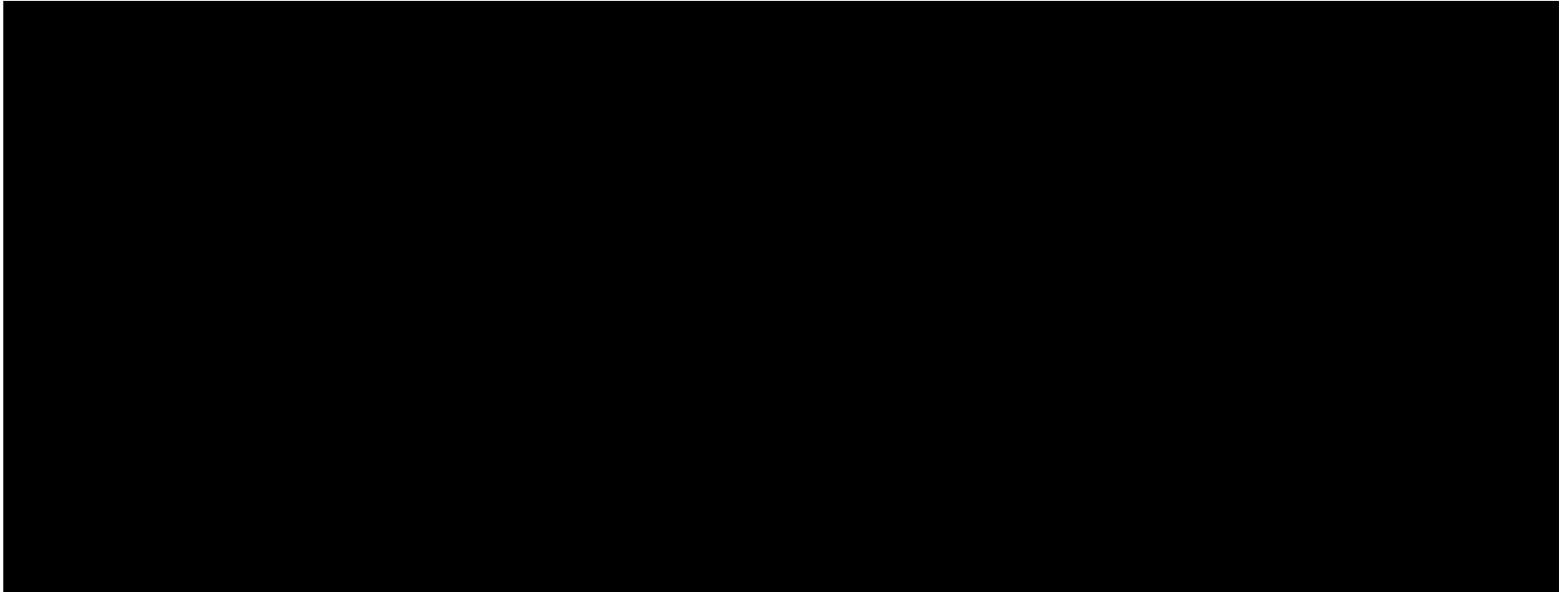
⁴³ FB-SINGER-00019177

⁴⁴ Data during that period is missing revenue for October 2016 and half of March 2019.

Because Professor Allenby estimated separate parameters for each effect, it would be possible to estimate the impact for the class of changing only one.⁴⁵ Additionally, because Facebook's "all_ads_data" contains details about the observable characteristics of the advertisers, I am also able to estimate damages for subgroups of advertisers based on criteria such as their volume of commerce, advertising objective and time of their campaign (if necessary).

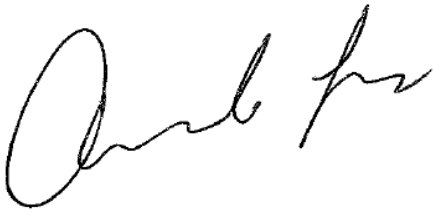
⁴⁵ Given that the average coefficients are roughly equal, I would anticipate estimated damages would be roughly half of what I have calculated.

Table 2: Facebook US Ad Revenue and Class-wide Damages 2014-2020 (\$ millions)



VII. CONCLUSIONS

56. I have reviewed Facebook's data and documents provided in discovery, the reports of Professor Greg Allenby and Professor Tim Roughgarden, and reviewed both public and academic sources to ascertain whether class-wide damages can be reliably estimated on a common class-wide basis. I find that they can, and the amount of class-wide damages from August 15, 2014 through December 22, 2020 amounts to \$3.8 billion dollars. I reserve the right to revise my opinion if new information becomes available to me.

A handwritten signature in black ink, appearing to read "Armando Levy".

Armando Levy, Ph.D.

December 22, 2020

APPENDIX A: CURRICULUM VITAE OF ARMANDO LEVY

Dr. Armando Levy, a Principal at The Brattle Group, specializes in microeconomics, econometrics, and statistics. Dr. Levy has provided testimony and supported the expert work of top academics in many litigation cases with an emphasis on statistical and econometric issues as well as sample design. His casework experience spans class action (class certification and damages), antitrust, environmental damages, product liability and intellectual property. Dr. Levy has recently been involved in the Packaged Seafood indirect purchaser, Milk indirect purchaser, MLB/NHL, LCD-TFT, SRAM (where he served as a damages expert) and DRAM antitrust actions in the U.S. as well as antitrust actions in Australia. Dr. Levy has also recently been involved in a Lanham Act matter involving infant formula and a Natural Resource Damages Assessment (NRDA) litigation involving the Deepwater Horizon oil spill. Dr. Levy has supported many top-tier academic experts including Professor Dan McFadden of Berkeley, Ariel Pakes of Harvard University and Professors Roger Noll and Robert Hall of Stanford. Dr. Levy has also recently provided written and deposition testimony at the class certification stage involving the measurement of the effect of false claims on consumer demand and prices. His academic work has examined issues in the demand for crop insurance, telecommunications and live theater. He has also analyzed bidding behavior in auctions, the diffusion of wireless technologies, and optimal contracts in the poultry industry.

Prior to joining The Brattle Group, Dr. Levy was Assistant Professor of Economics at North Carolina State University in Raleigh, North Carolina. Dr. Levy was a Medical Economics Analyst for Kaiser Permanente (Northern California) from 1989 – 1990. Dr. Levy was a lecturer at the University of California at Berkeley in 2008, 2009 and 2019.

Dr. Levy has authored a chapter for a book on demand analysis in the telecommunications industry and numerous articles for peer-reviewed journals. Dr. Levy earned his Ph.D. in Economics and a M.A. in Statistics both from the University of California at Berkeley.

AREAS OF EXPERTISE

- Antitrust
- Class Action Litigation
- Lanham Act and Product liability
- Commercial Damages
- Natural Resource Damage Assessments
- Intellectual Property
- Econometrics and Statistics
- Sample design, discrete choice models

EDUCATION

- 1996 Ph.D. Economics, University of California at Berkeley
- 1995 M.A. Statistics, University of California at Berkeley
- 1989 A.B. Applied Mathematics, University of California at Berkeley

EXPERIENCE

Antitrust

- *Blue Cross Blue Shield Antitrust Litigation*. Supported Professor Ariel Pakes in class certification, liability and damages from market segmentation.
- *Tuna Indirect Purchaser Antitrust Litigation*. Supported Professor David Sunding in class certification, liability and damages estimate from an alleged price-fixing.
- *National Milk Producers Antitrust Litigation*. Supported Professor David Sunding in damages estimate from supply restriction related to the Herd Retirement Program.
- *Laumann v. NHL/MLB Antitrust Litigation*. Supported Professor Dan McFadden in evaluation of proposed damages model for a Daubert hearing.
- *SRAM Class Action Litigation*. Performed damages analyses of alleged price fixing by SRAM manufacturers and rebuttal of defense experts' analysis.
- *DRAM Class Action Litigation*. Support damages analyses of alleged price fixing by DRAM manufacturers and rebuttal of defense experts' analysis.
- *eBay Class Action Litigation*. Support analysis to determine whether common issues predominate economic analysis of liability and damages for class certification. Provide testimony on utility of certain data for economic modeling.
- *LCD-TFT Antitrust Litigation*. Performed damages analysis to determine alleged overcharges from purchases of a large state and municipalities.
- *Microsoft v. Various States Class Action*. Analysis of anti-trust damages claims arising from multi-state class action litigation. Aided Professor Robert Hall in developing complex mathematical model of competition within the relevant market.
- *Noranda and DuPont v. Class Action*. Analysis of market for sulfuric acid. Support academic expert in calculation of industry costs and other issues. Aided in filing of expert report.

Lanham Act and Product Liability

- *PBM Products v. Mead Johnson*. Performed time series econometric analysis of sales of infant formula to identify impact of deceptive advertising.
- *General Motors Ignition Switch Litigation*. Analysis of methodology proposed to estimate impact and damages from delayed recalls of GM vehicles.
- *McCormick and Company Inc., Pepper Products Marketing and Sales Practice Litigation*. Analysis of whether common issue predominate in the calculation of impact from allegations of slack filling pepper containers
- *Hughes, et al. v. Ester C Company*. Analysis of issues related to plaintiffs' experts methodology to prove common impact and class-wide damages from alleged misrepresentations on product labels.

Environmental and Natural Resources Damage Assessments

- *Puget Sound Air Regulation*. Report filed to rebut economist's estimate of displacement of bunker fuel from natural gas conversion of maritime fleet,
- *Analysis of Carbon Leakage from Proposed Regional Regulations*. Analysis of EPA and other public information to assess carbon leakage from the effects of proposed regulations governing the petroleum industry.
- *Deepwater Horizon- Analysis of lost value from loss of recreational use*. Combine survey research and recreational count data to estimate the lost value to people from the loss of recreational use of a stretch of coastline.
- *Groundwater Contamination*. Design a survey instrument and sampling design to assess the value of an uncontaminated drinking water supply for a population of a suburban community.
- *Fishing Health Assessment*. Design a survey instrument and sampling design to assess exposure of recreational fishermen to contaminated river sediment borne through fish catches.

Intellectual Property

Smith & Nephew v. Hologic. Analysis of the degree of competition and pricing behavior between plaintiff's and defendant's products. Assess issue related to irreparable harm.

Resonate v. Alton Websystems. Analysis of issues relating to reasonable royalty calculation for a patent infringement claim regarding features of defendant's webswitch. Aided expert in filing report and providing deposition testimony. Created a stratified sample of customer service calls from client database to establish prevalence of disputed feature.

Reasonable Royalty for Packet Switching Technology. Analysis of issues relating to reasonable royalty calculation for a patent infringement claim regarding features of defendant's internet router. Aided expert in filing report. Created a stratified sample of customer service calls from client database to establish prevalence of disputed feature.

Valuation

Eric Spire v. County of Santa Clara. Analysis of breach of contract claim by music promoter against the county for rental of fairgrounds. Support expert in valuation of promoter's opportunity from rental agreement. Aid counsel in deposition of plaintiff's damages expert.

Business Interference

- *LT Game International Ltd. v. Shuffle Master, Inc.* Critique of damages analysis arising from claimed business interference in the market for gaming equipment.
- *PeopleSoft v. Oracle.* Analysis of damages arising from Oracle's unsolicited tendered offer for PeopleSoft. Aided academic expert in analysis of data and economic literature.

Mediation

- *Tobacco MSA Settlement Administration.* Analysis of the econometric determination of the source of lost market share for administration of the MSA for years 2004, 2005.

TESTIMONY

- *Advocate for Cleaner Air, et. al. v. Puget Sound Clean Air Agency, Puget Sound Energy* Declaration to rebut economist's estimate of displacement of bunker fuel from natural gas conversion of maritime fleet
- *In Re: McCormick & Company, Inc. (MDL No. 2665 Docket No. 1:15-mc-1825-ESH)* expert report and deposition: access whether or not class-wide damages could be calculated on a common basis. (June 2016 – January 2020)
- *FTC v. PBS Inc. (Case No. 2:08-cv-00620-APG-GWF)* expert report and deposition: estimate damages for customers of magazine retailer from misleading sales practices (December 2015- ongoing)
- *Hughes, et al. v. NBTY Inc. (Case No. 2:12-cv-00041-PKC-GRB)* declaration and deposition: rebuttal to opinion on class certification (November 2015 – September 2016)
- *Lyon, et al. v. United States Immigration and Customs Enforcement (Case No. 13-cv-05878 EMC)* expert report: report on distribution of incarcerations at detention facilities (November 2015 – June 2016)
- *Ambac v. Countrywide – New York State Court (Case No. 651612/2010)* expert report and deposition: evaluation of econometric analysis of Prof. Jerry Hausman (April 2015 – ongoing)
- *Jeffrey Sachs, et al. v. Toyota Motor Company. – California State Court (Case No. BC443701)* declarations: damages to named plaintiffs (July, 2014- March 2017)
- *LT Game International Ltd. v. Shuffle Master, Inc. -- U.S District Court, District of Nevada (Case No. 2:12-cv-01216-JAD-GWF)* co-authored (with Coleman Bazelon) expert report and deposition: evaluate damages analysis of economists (May, 2013-ongoing)
- *Rebuttal Testimony before the New Jersey Board of Public Utilities in a Water Tariff Proceeding (BPU Docket No. WR11070460 and OAL Docket No. PUC 09799-2011N)* Written testimony on the forecasting of future water demand by customers of New Jersey American Water Company (February 2012).
- *SRAM Class Action Antitrust Litigation—U.S. District Court, Northern District of California (Master File No. M:07-cv-01819-CW, MDL No. 1819)* Expert Reports and deposition: Estimated antitrust class action damages for SRAM due to alleged price-fixing collusion (January 2010-January 2011).
- *eBay Class Action Antitrust Litigation-- U.S. District Court, Northern District of California (Case No.07-CV-01882-JF (RS))* Declaration and deposition: Importance and relevance of certain data to estimate microeconomic models useful for market definition, measurement of market power and damages (June-August 2009).

- *Report submitted before the International Trade Commission-- Investigation Nos. 701-TA-447 and 731-TA-1116: An econometric study of the effects of Chinese imports of standard steel pipe (June 2008).*
- *Retailer Bankruptcy U.S. Bankruptcy Court, Northern District of Ohio-- Declaration: Offered opinion related to anomalies in a proffered inventory database (May 2007).*
- *Mortgage Lender Class Action Litigation-- Declaration: Offered opinion on effectiveness and reliability of random sampling of mortgage applications (2005).*

PUBLICATIONS

- “An Economic Treatment of Pass Through in Indirect Purchaser Antitrust Litigation” (joint with David Sunding) *Competition*, Vol. 30(1) (2020), 149-156.
- “Smart Pricing, Smart Charging Can time-of-use rates drive the behavior of electric vehicle owners?” (joint with Ahmad Faruqui, Ryan Hledik and Alan Median) *Public Utilities Fortnightly* October (2011), 38-45.
- “Do Farmers value the Environment? Evidence from the Conservation Reserve Program” (joint with Michelle Marra, Tom Vukina and Xiaoyong Zheng) *International Journal of Industrial Organization* Vol. 26(6) (2008), 1323-1332.
- “The League Composition Effect in Tournaments” (joint with Tom Vukina) *Journal of Labor Economics* Vol. 22(2) (2004), 353-378.
- “Wireless Diffusion and Mobile Computing: Implications for the Digital Divide” (joint with Jonathan Wareham and Wei Shi) *Telecommunications Policy* Vol. 28 (5,6) (2004), 439-457.
- “A Generalized Additive Tobit Model for Telecommunications” *Empirical Economics* Vol. 28(1) (2003), 3-22.
- “Tobit Without Apology” *economics letters* Vol. 77(3) (2002), 399-404.
- “Demand for Live Theater with Market Segmentation and Seasonality” (with Jonathan Corning) *Journal of Cultural Economics* Vol. 26 (2002), 217-235.
- “Optimal Linear Contracts with Heterogeneous Agents” (joint with Tom Vukina) *European Review of Agricultural Economics* Vol. 29(2) (2002), 205-217.
- “Who will be the Adopters of 3G Mobile Computing Devices? A Probit Estimation of Mobile Telecom Diffusion” (with Jonathan Wareham) *Journal of Organizational Computing and Electronic Commerce* Vol. 12(2) (2002), 161-174.
- “Parametric, Semi-parametric and Non-parametric Models of Telecommunications Demand: An Investigation of Residential Calling Patterns” (with Erik Heitfield) *Information Economics and Policy* Vol. 13 (2001), 311-329.
- “Semi-parametric Estimation of Intra-LATA Demand Elasticities” in The Future of the Telecommunications Industry: Forecasting and Demand Analysis edited by D. M. Loomis and L. D. Taylor, Kluwer Academic Publishers 1999.

WORKING PAPERS

- “What is Special about Today? Estimating Impacts from Demand Response Programs”
- “On the Limit Pricing of Goods with Network Effects”.
- “A Simple Consistent Estimator for the Regression Function in a Truncated Sample”.
- “A Semi-parametric Evaluation of Adverse Selection, Disaster Relief and the Demand for Insurance” (joint with Barry Goodwin).
- “Demand for Intra-LATA Telecommunications: Evidence and Policy Implications”.

SELECTED PRESENTATIONS

- Panel on Class Certification, Bar Association of Chicago, May 2020
- Panel on Class Certification in Antitrust Cases, Bar Association of San Francisco, November 2018
- Center for Research in Regulated Industries Conference, Monterey, CA, June 2014.
- Center for Research in Regulated Industries Conference, Monterey, CA, June 2012.
- CLE Presentation on Economic Evidence in class certification in anti-trust cases, Boston Bar Association, October 2011.
- Center for Research in Regulated Industries Conference, Monterey, CA, June 2011.
- International Industrial Organization Conference, Boston, MA, April 2011.
- International Telecommunications Society Conference, Montreal, Canada, June 2008.
- Western Economic Association Annual Conference, San Francisco, CA July 2005.
- University of California at Berkeley, Department of Environmental and Natural Resource Economics, Berkeley, CA. April, 2003.
- North Carolina State University, Departments of Economics and Agricultural Economics, Raleigh, NC. April, 2003.
- European Agricultural Economics Association Meetings, Copenhagen, Denmark June 2001.
- Department of Agricultural Economics, North Carolina State University, Raleigh, NC April 2001.

- The Federal Reserve Bank of San Francisco, San Francisco, CA February 2001.
- 8th World Congress of the Econometric Society, Seattle, WA, August 2000.

PROFESSIONAL AFFILIATIONS

- Econometric Society
- American Economic Association

APPENDIX B: DOCUMENTS RELIED UPON

Legal Documents

- Third Amended Consolidated Class Action Complaint In DZ Reserve and Cain Maxwell (d/b/a Max Martialis) individually and on behalf of others similarly situated v. Facebook, Inc., Case No.: 3:18-cv-04978
- Facebook Inc.'s Supplemental Responses and Objections to Plaintiffs' First Set of Interrogatories, Case No.: 3:18-cv-04978
- Facebook Inc.'s Second Amended and Supplemental Responses and Objections to Plaintiffs' Second Set of Interrogatories, Case No.: 3:18-cv-04978
- Facebook Inc.'s Amended and Supplemental Responses and Objections to Plaintiffs' Third Set of Interrogatories, Case No.: 3:18-cv-04978
- Facebook Inc.'s Responses and Objections to Plaintiffs' Fourth Set of Interrogatories, Case No.: 3:18-cv-04978
- Facebook Inc.'s Responses and Objections to Plaintiffs' Fifth Set of Interrogatories, Case No.: 3:18-cv-04978

Expert Reports

- Expert Report of Greg M. Allenby
- Expert Report of Tim Roughgarden

Depositions

- Deposition of Dr. Chinmay Karamde, Ph.D., September 18, 2020
- Deposition of Gerardo Zaragoza, October 20, 2020

Academic Articles, Books and Public Press

- Ambrus, A., Calvano, E. and Reisinger, M. (2016) "Either or Both Competition: A "Two-Sided" Theory of Advertising with Overlapping Viewerships" *American Economic Journal: Microeconomics*, Vol. 8(3): 189-222
- Athey, S., Calvano, E. and Gans, J.S. (2018) "The Impact of Consumer Multi-homing on Advertising Markets and Media Competition" *Management Science*, Vol. 64(4): 1574-1590
- Berry, S. Levinsohn, J. and Pakes, A. (1995) "Automobile Prices in Market Equilibrium" *Econometrica*, Vol. 63(4): 841-890
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- Phillips, Sara (2007) “A brief history of Facebook” *The Guardian* 25 July 2007
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- Rosa, Anthony De. “Facebook Brings New Ad Opportunities to Brands.” *Reuters*. Thomson Reuters, February 29, 2012
- IAB Internet Advertising Revenue Report Full Year Results (2012-2019)
- AdStage Paid Media Benchmark Reports (Q32018,Q42019)
-

SEC Filings, Annual Reports & Earnings Transcripts

- Facebook 10K (2012-2019)
- Amazon 10K (2012-2018)
- Google 10K (2012, 2015-2019)
- Transcripts from Facebook Earnings Calls (Q2 2016 – Q2 2020)
- Transcripts from Google Earnings Calls (Q2 2016 – Q4 2018)

Facebook Documents & Data

- FB-SINGER-00314707 (advertising budget file in FB-SINGER-028)

- FB-SINGER-026 (all_ads_details), FB-SINGER-028, FB-SINGER-042
- FB-SINGER-00300058-62
- FB-SINGER-00313499
- FB-SINGER-00272318-28
- FB-SINGER-00150228
- FB-SINGER-00088221-23
- FB-SINGER-00187566-73
- FB-SINGER-00186953-54
- FB-SINGER-00003746
- FB-SINGER-00103337-61, FB-SINGER-00228373
- FB-SINGER-00092773-4
- FB-SINGER-00019177
- FB-SINGER-00314675, FB-SINGER-00426663
- FB-SINGER-00087711
- FB-SINGER-00088787-91
- FB-SINGER-00186795-800
- FB-SINGER-00186887-90
- FB-SINGER-00186952-59
- FB-SINGER-00187005
- FB-SINGER-00187068-70
- FB-SINGER-00187088-90
- FB-SINGER-00187226
- FB-SINGER-00187566-78
- FB-SINGER-00084486-506
- FB-SINGER-00088690-706
- FB-SINGER-00103337-76
- FB-SINGER-00228373-77
- FB-SINGER-00092767-75
- FB-SINGER-00165823-33
- FB-SINGER-00150119-33
- FB-SINGER-00019177-8

- FB-SINGER-00181941-48
- FB-SINGER-00054435-52
- FB-SINGER-00122904-22
- FB-SINGER-00183561-96

Websites

- Bloomberg.com
- Facebook.com
- Google.com
- Stratechery.com

APPENDIX C: ESTIMATING THE DAILY ADVERTISING BUDGET

1. I provided an estimate of the distribution of daily advertising budgets for Facebook advertisers to Professor Roughgarden. These distributions are inputs into Professor Roughgarden's ad auction simulation model. I provided him with this information based on an analysis of internal data produced by Facebook.
2. I made use of advertising budget data produced as file FB-SINGER-00314707 in FB-SINGER-028 and the "all_ads_details" data produced as FB-SINGER-026. FB-SINGER-028 contained budgets in USD (on a weekly, per ad set, or per advertising campaign basis) which I merged with associated data in the "all_ads_details" data based on matching the unique advertiser, ad campaign (denoted as "campaign group" in the data), and ad set (denoted as "campaign" in the data) identifiers across both sets of data. In particular, ad set and ad campaign durations, which are needed to convert overall budgets into daily budgets, were found in the "all_ads_details" data so that conversion from overall to daily budgets could only take place in cases where budget data could be matched to the "all_ads_details" data.
3. The "all_ads_details" data covered ads whose creation dates spanned August 15, 2014 through May 15, 2019 and was produced in separate files where each file represented a different period of time (typically one month).⁴⁶ When I attempted to match the budget data to the "all_ads_details" data, I found that the budget data matched almost all of the records in the May 2019 data in "all_ad_details" but very few of the records in earlier months.⁴⁷ Because estimating daily budgets requires matching budget amounts against records in "all_ads_details", I chose to develop my estimated of the daily budget distribution using the May 2019 "all_ads_details" data⁴⁸.
4. Creation of the daily budget distribution consisted of aggregating daily budgets up to the advertiser level where budgets were either specified at the campaign or ad set level.

⁴⁶ File FB-SINGER-00314675 containing data for March 2019 was delivered to me corrupted where only approximately the first half of the records were readable and I was unable to get a replacement version prior to preparing this report. Further, FB-SINGER-026 entirely omitted data for October 2016 and I only received access to data for that period too late to incorporate into my report. (FB-SINGER-00426663 of FB-SINGER-042 was only made available as a 10+ GB file to download on December 19, 2020.) However, I do not believe its absence materially affects any of my calculations or conclusions.

⁴⁷ I found 99.9% of the May 2019 records were matched, 60.8% of the April 2019 records and 13.9% of the March 2019 records. Prior months continued to taper off monotonically with less than 1% of the earliest month's records being matched.

⁴⁸ The file Bates stamped FB-SINGER-00314677 in FB-SINGER-026.

Budgets specified on a weekly basis⁴⁹ were converted to a daily basis by simply dividing by 7 (days); otherwise budgets were divided by the campaign duration (in days) specified in the “all_ads_details” data.⁵⁰ When budgets were set at an ad set basis⁵¹ the computed daily budget was aggregated across ad sets and when they were set at a campaign level the computed daily budget was aggregated across ad campaigns. The result was the total daily budget by advertiser. As there were more than 1.2 million advertisers represented in the data sample, I ordered the advertisers by daily budget and split them into 500 groups of roughly equal numbers of advertisers and summarized each group with its range of daily budgets and the number of advertisers in the group. Professor Roughgarden used my results in this form as an estimate of the probability distribution of advertiser daily budgets in his auction simulations. I believe this gives a reasonable, representative estimate of the distribution of daily budgets by Facebook advertisers. This distribution is shown in Figure 8 below.

5. As can be seen in Figure [REDACTED] are quite typical daily advertising budgets in the data. However, the Facebook data I was provided reports advertisers with budgets up to over [REDACTED] per day. However, the data for the advertisers reporting the highest daily budgets are unreliable. For example, the advertiser the data claims has the highest daily budget, a daily budget of over [REDACTED] per day (anon_account_id = "e2b3MUzasz8=") has 100 ad sets in the data of which 9 reported budgets over [REDACTED] per day while having total spending ranging from [REDACTED]. Furthermore, two of the five advertisers (anon_account_id = "za2bmCjb4qU=" and anon_account_id = "i/guNesIaVw=") which the data suggests have the highest daily ad budgets report zero spending in the data. Based on the unreliability of the data reporting the highest daily ad budgets, I recommended to Professor Roughgarden that he exclude from consideration the data for the highest reported daily advertising budgets. The median daily budget is [REDACTED] per day, the 80th percentile daily budget is [REDACTED] day, the 90th percentile is [REDACTED] per day, the 95th percentile is [REDACTED] per day.

⁴⁹ As defined by the field “paceable_limit_reset_period” in the “all_ads_details” data: the budget amount in field “paceable_limit_value_usd” is a weekly budget when this field equals “168” – see p. 99 line 21 through p. 100 line 8 of the Deposition of Gerardo Zaragoza taken on October 20, 2020.

⁵⁰ In some cases, the campaign end date in “all_ads_details” was coded as “1969-12-31 16:00:00” which I interpreted as a missing value code. In creating the distribution of daily budgets, I omitted cases where the budget covered the entire campaign duration but the campaign end date was missing.

⁵¹ As defined by the field “paceable_limit_level” in the “all_ads_details” data: the budget applies to an ad campaign when the field equals “CAMPAIGN_GROUP” and it applies to an ad set when the field equals “CAMPAIGN” – see p. 99 lines 16-20 in the Zaragoza Deposition.

Figure 8: Estimated Facebook Daily Campaign Budget

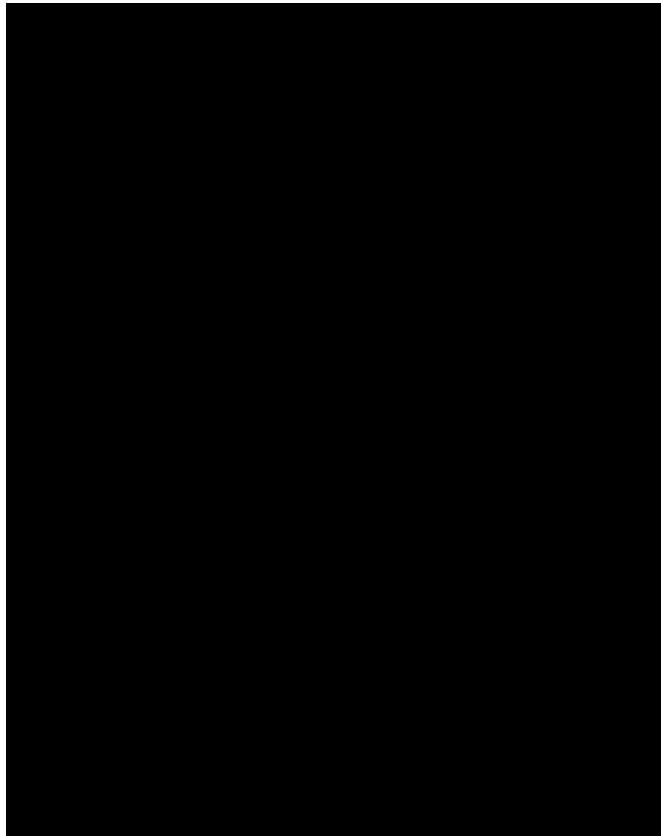


APPENDIX D: SUMMARY TABLES USING FACEBOOK ADVERTISER DATA

1. This appendix displays some tables derived from the *all_ads_details* file.

Table 3: Revenue Summary





Sources and Notes:

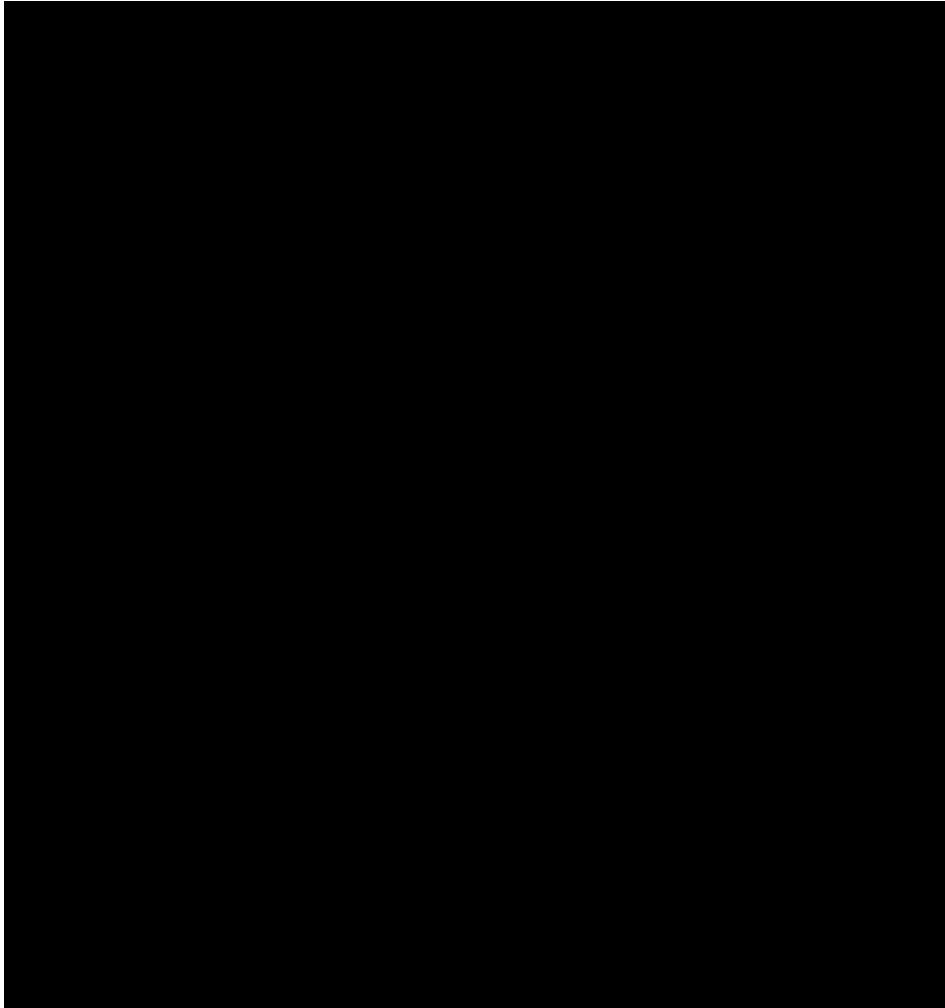
FB-SINGER-026, containing files FB-SINGER-00314652 to FB-SINGER-00314704.

File FB-SINGER-00314675 containing data for March 2019 was delivered to me corrupted such that only the first half of the records were readable. However, the readable data covered the entirety of the month and I do not believe its absence materially affects any of my calculations or conclusions.

FB-SINGER-026 entirely omitted data for October 2016 and I only received access to data for that period too late to incorporate into my report. (FB-SINGER-00426663 of FB-SINGER-042 was only made available as a 10+ GB file to download on December 19, 2020.) However, I do not believe its absence materially affects any of my calculations or conclusions.

Table 4: Metrics Summary by Reach & Frequency Campaign Indicator

Month	<i>R&F Campaign Indicator of 0</i>	<i>R&F Campaign Indicator of 1</i>
	Impressions (M)	Impressions (M)
[A]	[B]	[C]
[REDACTED]		



Sources and Notes:

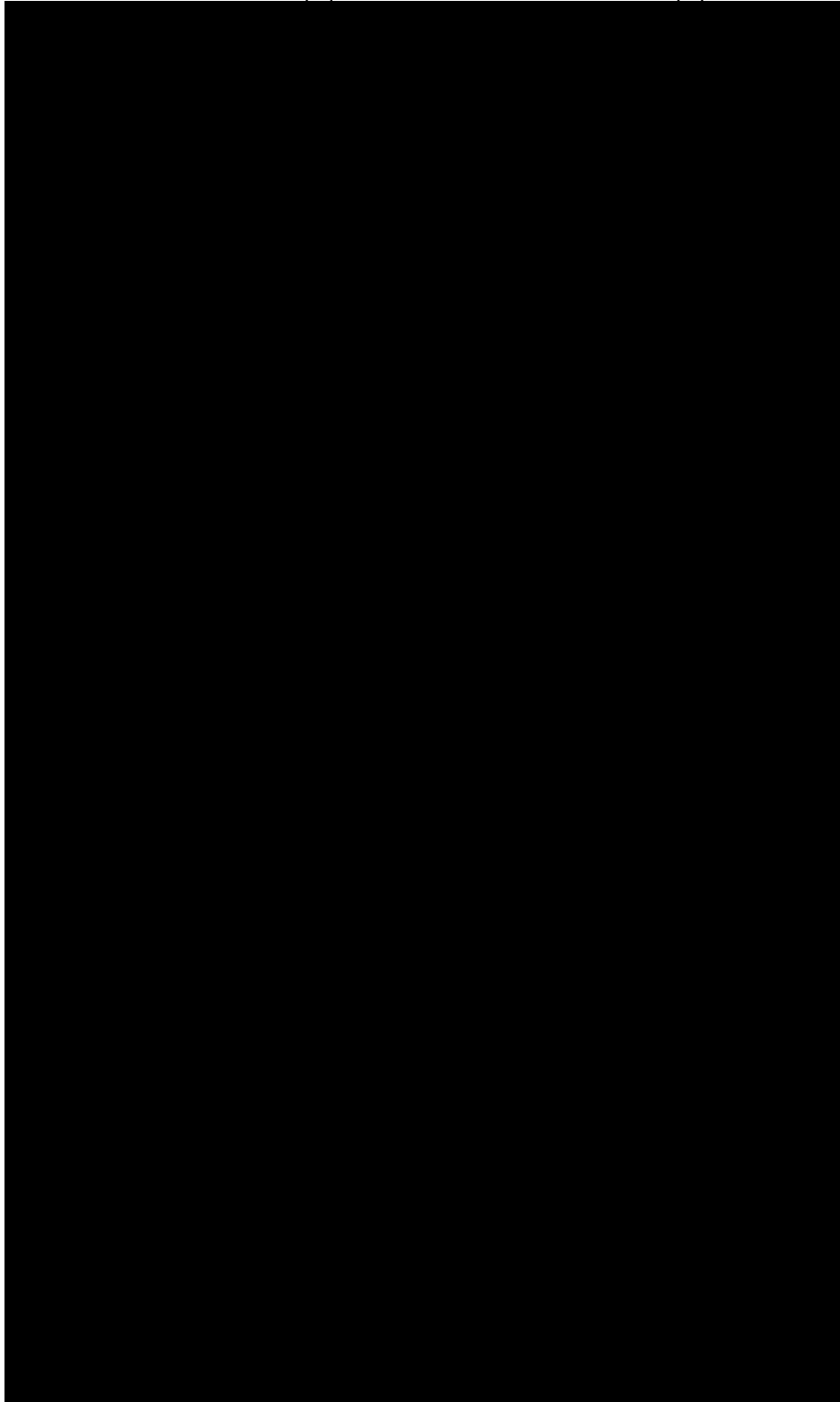
FB-SINGER-026, containing files FB-SINGER-00314652 to FB-SINGER-00314704.

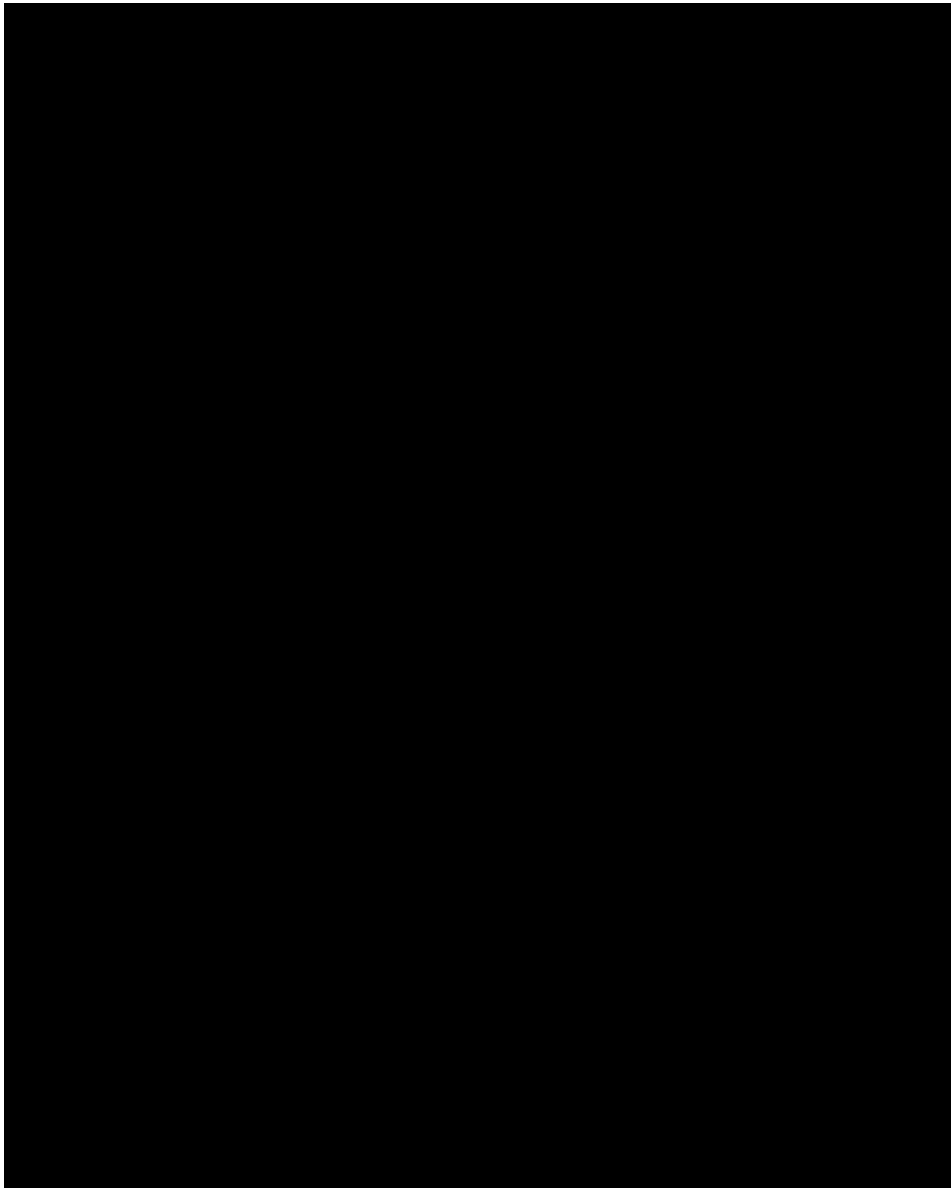
File FB-SINGER-00314675 containing data for March 2019 was delivered to me corrupted such that only the first half of the records were readable. However, the readable data covered the entirety of the month and I do not believe its absence materially affects any of my calculations or conclusions.

FB-SINGER-026 entirely omitted data for October 2016 and I only received access to data for that period too late to incorporate into my report. (FB-SINGER-00426663 of FB-SINGER-042 was only made available as a 10+ GB file to download on December 19, 2020.) However, I do not believe its absence materially affects any of my calculations or conclusions.

Table 5: Revenue by Source App

Source App	Revenue (USD)
[A]	[B]





Sources and Notes:

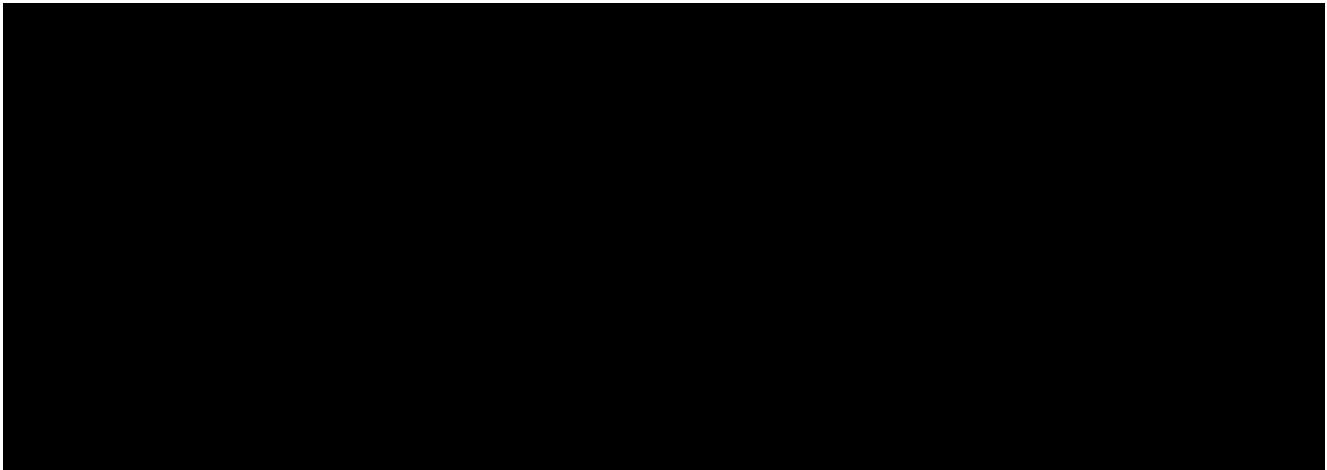
FB-SINGER-026, containing files FB-SINGER-00314652 to FB-SINGER-00314704.

File FB-SINGER-00314675 containing data for March 2019 was delivered to me corrupted such that only the first half of the records were readable. However, the readable data covered the entirety of the month and I do not believe its absence materially affects any of my calculations or conclusions.

FB-SINGER-026 entirely omitted data for October 2016 and I only received access to data for that period too late to incorporate into my report. (FB-SINGER-00426663 of FB-SINGER-042 was only made available as a 10+ GB file to download on December 19, 2020.) However, I do not believe its absence materially affects any of my calculations or conclusions.

Table 6: Revenue Buckets

				Average Revenue per
Ad Year	Revenue Bucket	Revenue (USD)	Number of Advertisers	Advertiser
[A]	[B]	[C]	[D]	[E]



Sources and Notes:

FB-SINGER-026, containing files FB-SINGER-00314652 through FB-SINGER-00314704.

File FB-SINGER-00314675 containing data for March 2019 was delivered to me corrupted such that only the first half of the records were readable. However, the readable data covered the entirety of the month and I do not believe its absence materially affects any of my calculations or conclusions.

FB-SINGER-026 entirely omitted data for October 2016 and I only received access to data for that period too late to incorporate into my report. (FB-SINGER-00426663 of FB-SINGER-042 was only made available as a 10+ GB file to download on December 19, 2020.) However, I do not believe its absence materially affects any of my calculations or conclusions.

[E]: Calculated as [C] / [D].

Table 7: Highest Spenders by Month

Month	Advertiser ID	Advertiser Spending	Total Spending	Percent of Total Spending

Sources and Notes:

FB-SINGER-026, containing files FB-SINGER-00314652 through FB-SINGER-00314704.

File FB-SINGER-00314675 containing data for March 2019 was delivered to me corrupted such that only the first half of the records were readable. However, the readable data covered the entirety of the month and I do not believe its absence materially affects any of my calculations or conclusions.

FB-SINGER-026 entirely omitted data for October 2016 and I only received access to data for that period too late to incorporate into my report. (FB-SINGER-00426663 of FB-SINGER-042 was only made available as a 10+ GB file to download on December 19, 2020.) However, I do not believe its absence materially affects any of my calculations or conclusions.

[B]: Indicates the advertiser with the highest spending in a given month.

[C]: Monthly spend amount by [B].

[D]: Monthly spend amount by all advertisers.

[E]: Calculated as [C] / [D].

Table 8: Ad Sets and Impressions

Month	Ad Sets	Impressions (K)	Ratio of Ad Sets to Impressions
[A]	[B]	[C]	[D]



Sources and Notes:

FB-SINGER-026, containing files FB-SINGER-00314652 to FB-SINGER-00314704. File FB-SINGER-00314675 containing data for March 2019 was delivered to me corrupted such that only the first half of the records were readable. However, the readable data covered the entirety of the month and I do not believe its absence materially affects any of my calculations or conclusions.

FB-SINGER-026 entirely omitted data for October 2016 and I only received access to data for that period too late to incorporate into my report. (FB-SINGER-00426663 of FB-SINGER-042 was only made available as a 10+ GB file to download on December 19, 2020.) However, I do not believe its absence materially affects any of my calculations or conclusions.

[B]: Indicates the number of unique ad sets, as recorded by campaign_id, in a given month.

[C]: Indicates the number of impressions, as recorded by lifetime_legal_impressions / 1000, in a given month.

[D]: Calculated as [B] / [C].

Table 9: Average Cost Per Thousand Impressions (CPM)

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Sources and Notes:

FB-SINGER-026, containing files FB-SINGER-00314652 to FB-SINGER-00314704.

File FB-SINGER-00314675 containing data for March 2019 was delivered to me corrupted such that only the first half of the records were readable. However, the readable data covered the entirety of the month and I do not believe its absence materially affects any of my calculations or conclusions.

FB-SINGER-026 entirely omitted data for October 2016 and I only received access to data for that period too late to incorporate into my report. (FB-SINGER-00426663 of FB-SINGER-042 was only made available as a 10+ GB file to download on December 19, 2020.) However, I do not believe its absence materially affects any of my calculations or conclusions.